Province of British Columbia

Water Management Branch

DESIGN GUIDELINES FOR RURAL RESIDENTIAL COMMUNITY WATER SYSTEMS

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FOR

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MAP OF BRITISH COLUMBIA SHOWING CLIMATIC ZONES

FOREWORD

These guidelines cover the design of new waterworks systems or extensions and replacement works to existing systems providing domestic water service for low density housing in rural areas. They have specific application for water utility systems, are appropriate to improvement districts and are generally applicable to most rural residential water systems operated by regional districts or municipalities.

In general, the contents herein are intended to augment pertinent, commonly accepted standards such as those published by the American Water Works Association and other related agencies in the United States as well as Canadian federal and provincial governments. This document provides minimum values, below which a rural community water system should not be designed. The information will be reviewed periodically and amended as necessary in response to appropriate input from consulting engineers and other related technical agencies.

The jurisdictions regulating waterworks systems in British Columbia may be summarized as follows:

The Water Management Branch is responsible for the technical aspects of waterworks systems including all the licensing and regulation of the provincial water resource, and the regulation of water utilities under the Water Utility Act. The relevant legislation is generally administered by the Comptroller of Water Rights in Victoria and the Regional Water Managers located in five regions throughout the province.

The Ministry of Health is responsible for the health aspects of public water supply. On behalf of the Minister, the local Medical Health Officers have a related approval and monitoring role with regard to water quality.

Other government agencies have jurisdiction over various aspects of public water supply. These authorities include but are not necessarily limited to the following:

- Ministry of Municipal Affairs - re general administration of municipal water supply agencies.
- Ministry of Transportation and Highways - re highway crossings, pipeline routes in public roads, and some subdivision approvals.
- Ministry of Municipal Affairs - re Safety Engineering Services.
- Regional Districts (see Municipal Affairs).
- Improvement Districts (see Municipal Affairs).
- Municipalities (see Municipal Affairs).
- Workers Compensation Board of B.C. - re construction safety practices.

The electrical system must be designed and constructed to the approval of the local electrical inspection authority.

In these guidelines, the use of "shall" or similar imperative implies a statutory requirement. The use of "should" indicates a strong recommendation.

1. SOURCE OF SUPPLY

The design engineer should show that an adequate quantity of water will be available to meet the demand.

1.1 Surface Water

A hydrology study by a professional hydrologist may be required to confirm the availability of water.

The reliable yield of the source, after th flow has been regulated by any seasonal balancing storage, should be adequate to supply the design maximum day demand during a moderate drought. A "moderate drought" is considered to be a period of stream flow so low that only with an average frequency of once in ten years would the regulated flow be as low.

1.2 Groundwater

Wells should be located, constructed, tested and disinfected in general accordance with the "Guidelines for Minimum Standards in Water Well Construction, Province of British Columbia". The well should be at least 100 feet from possible sources of contamination.

The total developed groundwater capacity or "dependable yield" of well(s) should equal or exceed the design maximum day demand. Normally, the groundwater source(s) should be capable of sustaining this rate of flow continuously for 100 days during which the aquifer was not being recharged by precipitation and without utilizing more than 70% of the available drawdown below the lowest seasonal static groundwater table.

1.3 Quality

The publication "British Columbia Drinking Water Quality Standards" should be used as a guideline for evaluation of water delivered to the consumer.

In general, these standards require that water supplies for drinking, culinary and other domestic uses, be free of pathogenic organisms and their indicators and deleterious chemical substances including radioactive materials. In addition, the water should not have an objectionable colour, odour or taste and should be neither unduly corrosive nor unduly encrusting.

1.4 Impounding Reservoirs

Impounding reservoirs should be designed to prevent, insofar as it is practicable, deterioration of raw water quality by minimizing contact with organic materials (grass, peat, trees, etc.), avoiding shallow water areas and embankment erosion.

1.5 Treatment

Where it is proposed to add chemicals and/or foreign materials to a water or to treat a water supply in any other manner, the proposal must receive prior approval. In some instances, the provision of treatment may be a condition of source approval.

2. DEMAND

The projected demand should preferably be estimated from reliable records of present consumption in representative community water systems, and should be sufficient to satisfy the reasonable expectations of all residents to be served. When reliable records are not available, the design engineer should, following a study of the needs of the service area, prepare and submit his estimates of average day, maximum day and peak hour demands. These may include but not necessarily be limited to:

a. indoor household use,
b. outdoor residential uses, including lawn and garden watering,
c. replenishment of reserve storage, and
d. allowance for losses due to such things as leakage, flushing of water mains, streets and sewers, and backwashing of filters, etc.

2.1 Indoor Household Use

Basic in-house use is well established at about 230 litres (50 Imp. gal.) per capita per day and varies only slightly with locality.

2.2 Lawn and Garden Watering

By far the largest portion of maximum day use will be for lawn and garden watering. The quantity needed depends on the area to be watered, climate during growing season, soil type and a number of less significant variables.

The quantity of water needed for lawn and garden watering may be obtained by multiplying the area to be watered by the appropriate irrigation rate within the range given in Table 1 for each of the three climatic zones shown on the map of British Columbia attached.

TABLE 1 - PEAK IRRIGATION REQUIREMENTS

	Irrigation Rate Per Day			
Climatic Zone	at 70% efficiency		at 50% efficiency	
	m^3/ha	Imp. gal/ac	m^3/ha	Imp. gal/ac
Temperate (except wet coastal and northern areas)	61- 73	5,500- 6,500	86-102	7,700- 9,100
Intermediate	76- 87	6,800- 7,800	106-122	9,500-10,900
Arid	91-116	8,100-10,400	126-163	11,130-14,000

The rates are given for two efficiencies of application: 70%, as in a well managed sprinkler system, and 50%. To water with 70% efficiency, home gardeners must exercise considerable restraint, which cannot usually be achieved without metering. Unless all service connections are to be individually metered, only 50% watering efficiency may be expected, because lawns and gardens will usually be watered more extravagantly and with less attention to control waste.

The lower rate of a given range in Table 1 applies at higher elevations or adjacent to the next wetter zone. The higher rate applies in the valley floor or adjacent to the next drier zone.

Irrigation rates are not available for northern or wet coastal areas, where water requirements are minimal.

2.3 Requirements for Maximum Day Demand

The design maximum day demand should consist of adequate water for lawn and garden watering plus a minimum of 1.1 m^3 (250 Imp. gal.) per day per single dwelling unit for all other purposes.

Except where otherwise evident, the lawn and garden area assumed to need watering should normally be:

a. for each single family detached house 0.04ha (0.1 acre), and

b. for high density development (ie. mobile home parks and multi family dwellings such as duplexes, apartment buildings or condominiums) all available land not occupied by buildings, driveways, etc.

Table 2 gives a normal range of acceptable quantities for the design maximum day demand for single family detached housing. These are total quantities required for all purposes in most circumstances.

To determine an acceptable design maximum day demand for high density housing, 1.1 m^3 (250 Imp. gal.) per day for each single family dwelling should be added to the quantity needed for lawn and garden watering of the entire irrigable area.

TABLE 2 - DESIGN MAXIMUM DAY DEMAND FOR TYPICAL SINGLE FAMILY DETACHED HOUSING

Climatic Zone	Maximum day demand per dwelling			
	All services metered (watering efficiency 70%)		No meters (watering efficiency 50%)	
	m^3	Imp.gal.	m^3	Imp.gal.
Temperate (except northern or wet coastal areas)	3.6-4.1	800- 900	4.6-5.3	1,000-1,150
Intermediate	4.2-4.7	950-1,050	5.4-6.1	1,200-1,350
Arid	4.8-5.9	1,050-1,300	6.3-7.8	1,400-1,700

2.4 Large Lots

The quantities in Table 2 include for watering of average 0.04ha (0.1 acre) gardens. It would be advisable to provide water for larger gardens in subdivisions of arable land into large single family lots, ie. lots over 0.12ha (0.3 acre). With

the exception of "hobby farms", more than 0.1ha (0.25 acre) of lawn and garden watering per dwelling is seldom required.

3. INTAKES

Intake works should be designed to optimize water quality, minimize maintenance and adverse environmental impacts, and not obstruct the passage of vessels in navigable waters. To limit the disturbance to the aquatic environment, intakes should be sized for the ultimate capacity of a waterworks system to be expanded in stages.

River intakes should be sited in a stable reach of the channel, where erosion or deposition will not endanger the works and in such a way that the natural regime of the river will not be upset.

Screens should be designed to be readily cleaned, preferably self-cleaning.

Submerged intake pipes in rivers and lakes should be graded to prevent accumulation of gasses and be adequately anchored or buried. Provision should be made to remove sediment by back flushing or other means.

Intake works should be protected against unauthorized persons and pollution from domestic, industrial or other harmful wastes or runoff and should be reasonably accessible in all seasons.

4. DISINFECTION OF WATER SUPPLY

4.1 Surface Water (including shallow wells)

All new surface water sources and unprotected groundwater (shallow wells) intended for new or existing domestic waterworks systems, shall be disinfected as required by the Medical Health Officer.

Exemptions from this requirement will be considered upon receipt of information to show conclusively that (a) the source is adequately protected from contamination and (b) bacteriological quality at the source meets water quality standards.

4.2 Ground Water (deep wells)

Where the Medical Health Officer considers it necessary for sanitary control, a deep-well groundwater source of domestic supply will require disinfection.

4.3 Means of Disinfection

Chlorine is the most commonly used disinfecting agent. Chlorination may be accomplished with sodium or calcium hypochlorites or with liquid (gas) chlorine. Other disinfectants, including ozone and ultra violet, may be considered. Liquid (gas) chlorine facilities should be restricted to water systems where qualified operators will be available to operate and maintain the equipment on an ongoing basis and who are trained and equipped to handle any emergency.

If chlorine disinfection is proposed, at least 20 minutes of contact should be provided prior to the first consumer. The free chlorine residual after 20 minutes of contact should not be less than 0.5 mg/L. A chlorine test kit using D.P.D. reagents should be provided.

Where the rate of water flow is variable, automatic proportioning equipment should be used.

Sodium and calcium hypochlorite facilities should include a cool, dark, dry, clean and vented area for the storage and use of the hypochlorite disinfectant. Calcium hypochorite facilities should also include covered make-up and feed solution tanks.

All chlorine handling and storage facilities shall conform to the requirements of the Workers' Compensation Act.

5. PUMPS

5.1 Number of Units

Wherever water is to be supplied by pumping, preferably at least two pumping units should be installed. With any pump out of service, the remaining pump(s) should be capable of delivering the average daily demand. In the selection of new pumps, reasonable allowance should be made for depreciation of output capacity due to wear.

Where only one pump unit is to be installed, consideration should be given to keeping a spare replacement unit on-site ready for immediate installation.

5.2 Individual Home Booster Pumps

Individual home booster pumps will not normally be acceptable for any individual service connection.

5.3 Protection

Pumping facilities should be designed to maintain the sanitary quality of the pumped water. Subsurface pits should not be incorporated in the design unless necessary. A pumping station should be protected from flooding.

6. ELECTRICAL

6.1 Design

The electrical system should be designed by a qualified electrical engineer or technologist conversant with the objectives of the water system. See Appendix 1 for detailed electrical design guidelines.

6.2 Auxiliary Power

Where electric supply failure may be expected to be frequent and would result in cessation of minimum essential service, a standby or auxiliary source of power should be provided.

7. DISTRIBUTION STORAGE

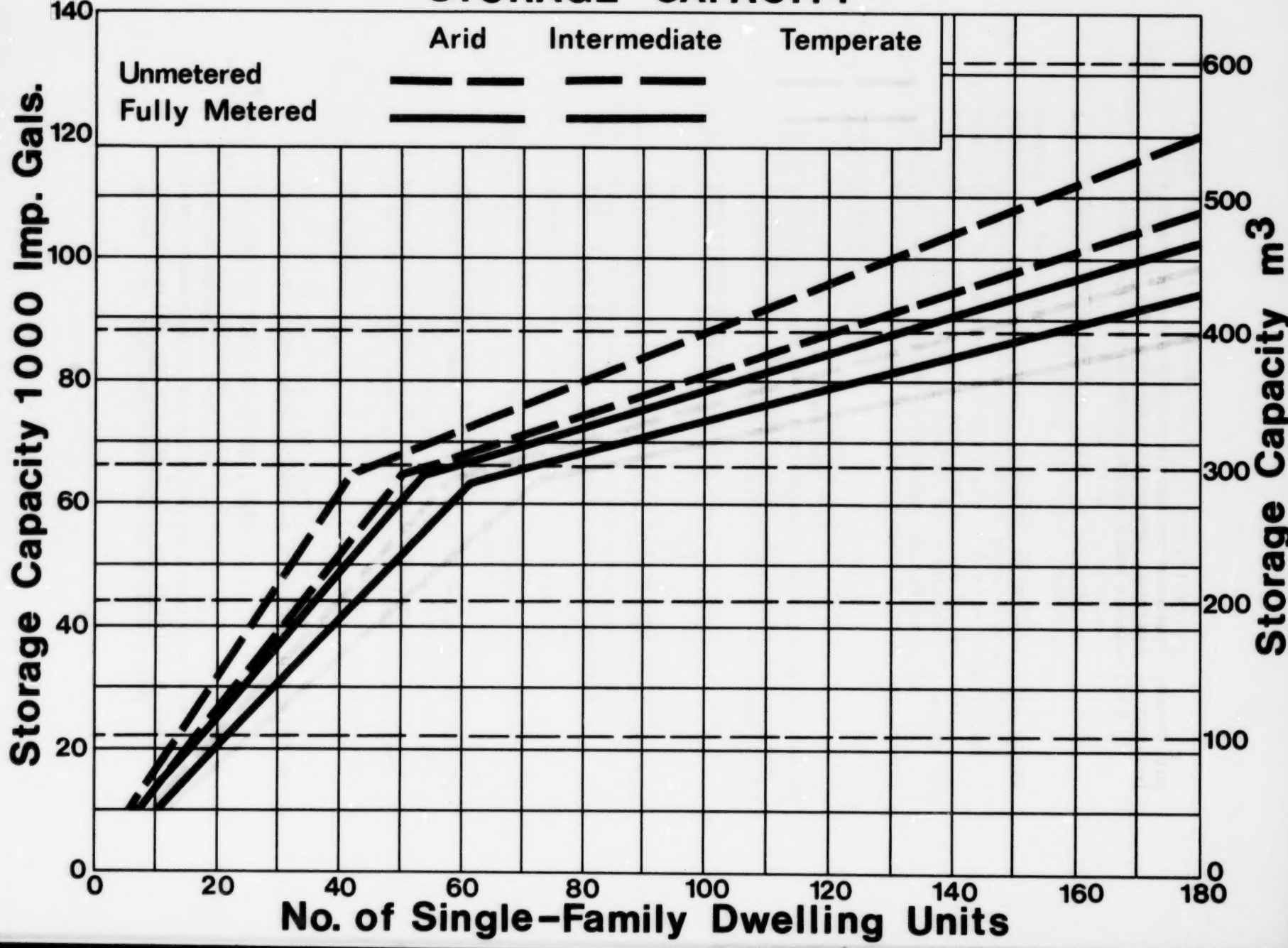
Finished-water storage facilities should have sufficient capacity, as determined from engineering studies, to control the operation of pumps, meet domestic demands and provide a reserve. This storage should be reliably available, preferably by gravity. If site conditions preclude elevated storage, pumping from ground level storage may be considered, in which case auxiliary power should be provided.

7.1 Storage Capacity

Unless otherwise determined from engineering studies, the volume of storage required to control pumps, balance fluctuations in domestic demand and

FIGURE 1

STORAGE CAPACITY



stabilize pressures should not be less than 25% of the maximum day demand.

In addition, except in small systems as noted below, in systems supplying detached single family dwellings the volume of reserve storage recommended is 220 m^3 (48,000 Imp gal.). Additional storage may be required to protect areas of enhanced population density such as townhouses, apartments and institutional buildings.

In small systems, supplying from 5 to about 50 dwellings, where it would be uneconomic to meet the foregoing storage requirements, the storage may be reduced to a volume equal to the maximum day demand but, in any event, should not be less than 45 m^3 (10,000 Imp. gal.).

Based on the maximum day demand given in Table 2 and the foregoing reserve storage objectives, the volume of storage shown in Figure 1 should satisfy normal requirements.

7.2 Pressure Tanks

Hydropneumatic tanks are acceptable as a means of pump control but not for providing balancing and reserve storage capacity, no matter how small the system.

7.3 Reservoir Design

Structural components and water level controls should be protected from freezing. Wherever practical, reservoirs should be constructed with more than one cell for ease of maintenance. Access hatches in the roof should be elevated to prevent drainage water from entering the reservoir. Vents must be designed to exclude birds, vermin and dust. Overflows and drains must be capable of safely discharging the greatest possible inflow and must not have a direct connection to a sewer or storm drain.

8. DISTRIBUTION PIPE

All water distribution pipes, including service connections, should be sized according to flow demands and pressure requirements.

8.1 Pressure

The system should be designed to maintain a minimum residual pressure of 140 kPa (20 p.s.i.) at ground level at all points in the water authority's distribution system under all conditions of flow, including a fire flow of 1.8 m^3 (400 Imp. gal.) per minute. At locations where buildings are to be equipped with automatic sprinkler systems for fire protection, a higher pressure may be required in the distribution mains during the fire flow than would otherwise be required where the fire protection is to be provided by water pumped from hydrants.

The normal working pressure (ie. under ordinary conditions of flow, excluding fire flow) in the water authority's distribution system should be ideally about 400 kPa (60 p.s.i.) but within a range between a minimum of 250 kPa (35 p.s.i.) and a maximum of 700 kPa (100 p.s.i.). In steep terrain, where dwellings are expected to be sited at an elevation above the distribution system, a minimum working pressure greater than 250 kPa (35 p.s.i.) may be required. Further, to reduce the number of pressure zones required and where only a relatively few sites would receive pressure exceeding 700 kPa (100 p.s.i.), that upper limit may be increased a little.

A steady working pressure is desirable. Fluctuations should not exceed 20% of normal at the water authority's shut-off on a consumer's service connection.

8.2 Minimum Size of Distribution Mains

The minimum diameter of distribution mains should be 150 mm (6 inch), except within 100 mm (300 feet) of a cul-de-sac or other dead end termination at a body of water, ravine, railway embankment or similar construction precluding the possibility of future extensions, where 100 mm (4 inch) may be used.

8.3 Minimum Size of Service Pipes

In determining the affordable pressure loss in the service pipe between the distribution main and the consumer's property line (and hence the minimum pipe size) consideration should be given to the

probable location of dwelling(s) on the consumer's lot, the working pressure in the main, and whether or not a water meter is to be installed.

The minimum size of service pipe should be 20 mm (3/4 inch).

9. WATER WORKS FOR FIRE PROTECTION

9.1 Hydrants

Tees with minimum 150 mm (6 inch) outlets for fire hydrants should be provided in the distribution pipe at suitable locations for fire fighting and not more than 300 m (1,000 feet) apart measured along public access routes. Where a fire fighting organization exists or is proposed in the vicinity, hydrants should be installed; otherwise standpipes should be installed on the hydrant tees.

Where practical, hydrants and standpipes should be located for the dual purpose of fire fighting and system flushing. (Hydrants need to be exercised occasionally and serviced after use.)

The hydrant lead should be minimum 150 (6 inch) diameter. Isolation valves should be installed on all hydrant leads.

Fire hydrants should be of a dry barrel type and have at least two 60 mm (2 1/2 inch) nozzles with British Columbia standard fire hose thread.

9.2 Standpipes

The standpipe lead should be minimum 50 mm (2 inch) diameter. Key operated isolation valves should be installed on all standpipe leads.

Standpipes should be minimum 50 mm (2 inch) diameter galvanized steel or ductile iron, of a dry barrel type and self draining. The outlet should have a British Columbia standard 60 mm (2 1/2 inch) fire hose thread, and cap securely fastened to the standpipe while permitting free rotation.

10. WATER METERS

10.1 Metering of Supply

Acceptable means of metering and recording the supply of water taken from the source should be provided.

10.2 Consumers Services

Where the source of water is limited or where it is desired to control consumption for other reasons, water meters on individual service connections may be required.

11. MATERIALS

All waterworks materials including steel tanks, lining materials, pipe (except PVC as noted below), fittings, valves and hydrants should conform to the latest standards of the American Water Works Association, or, in the absence of applicable A.W.W.A. standards, to such other standards as may be approved.

All electrical equipment and materials shall be approved by the Canadian Standards Association or specially approved by the Electrical Safety Branch.

Hydropneumatic tanks shall be constructed to comply with B.C. Power Engineers and Pressure Vessels Safety Act.

Painting and coating of all steel tanks should comply with A.W.W.A. standards for Painting and Repainting Steel Tanks, Standpipes, Reservoirs and Elevated Storage Tanks for Water Storage.

Polyvinyl Chloride (PVC) pressure pipe shall be manufactured to the standards of the A.W.W.A. or Canadian Standards Association. To conform with the safety factor against bursting as in the A.W.W.A. Standard, the nominal working pressure of the C.S.A. pipe shall be reduced as follows:

C.S.A. Series	Allowable Sustained Working Pressure (static plus pumping)	
	kPa	psi
125	500	76
160	700	100
200	900	128

The foregoing allowable working pressures include an allowance for surge pressure rise of approximately 200 kPa (30 psi).

All material must be suitable for use in potable water systems.

Except for certain mechanical and electrical equipment, all waterworks components should have a useful life expectancy of at least 25 years.

12. INSTALLATION

Specifications should incorporate the provisions of A.W.W.A. standards or a manufacturer's recommended installation and testing procedures.

All water works should be adequately protected from freezing. Buried pipe should be installed below the maximum depth of frost penetration except where special precautions are taken such as insulating the pipe.

Unless impractical, water pipes should be laid at least 3 m (10 feet) horizontally from any sewer or storm drain.

Where water and sewer pipes cross or share the same trench, the water pipe should be at least 0.5 m (18 inches) from the sewer pipe and should be located to the opposite side of a common trench. In these circumstances, the water main may require special protective measures.

12.1 Disinfection of Works

All new or newly repaired waterworks system components shall be disinfected according to A.W.W.A. standards or other equivalent method before being put into use.

To prevent environmental hazard, disinfection water should not be discharged directly or indirectly into streams, rivers or lakes without prior treatment to reduce to acceptable limits, or to remove, detectable residual chlorine.

13. SYSTEM LAYOUT

13.1 Pressure Zoning

Where, due to steep terrain, system operating pressures would otherwise exceed the acceptable maximum, the system should be divided into convenient differential pressure zones, separately metered and preferably with each zone individually supported by storage facilities.

13.2 Simplicity of Layout and Operation

A simple layout is desirable. There should be a minimum number of dead ends, no partially open valves between pressure zones and no normally closed valves within a zone. Mechanical and special devices, which require frequent attention, especially those placed underground, should be kept to a minimum.

13.3 Water Services Planning

Wherever practicable, water systems should be planned to facilitate emergency exchange of water between, and possible eventual integration with, neighbouring community water systems.

13.4 Looping

Distribution pipes should be looped where practical.

Where dead ends exist, standpipes or hydrants should be provided for flushing purposes.

13.5 Distribution Valving

Valves should be installed in the distribution system in accessible locations such that conveniently sized segments of the system can be isolated for ease of maintenance and repair.

13.6 Air and Vacuum Valves

At high points in water mains where air can accumulate, properly sized air release valves should be installed to vent the pipe on filling and to release accumulated air under operating pressure, and vacuum relief valves to introduce air on draining. These functions may be combined in a single air valve.

13.7 Location within Public Rights-of-Way

Wherever practical, all distribution pipe, including the water authority's portion of service pipe to consumers, should normally be laid within road allowances and other public rights-of-way, existing or planned. Where future relocation or degrading of a public road may be expected, however, installing pipes within an easement over adjoining private land could be preferable.

Works owned and operated by the water authority normally terminate at, and include, a curb stop-and-drain valve and valve box located adjacent to and just outside the consumer's property line, with the exception that the water authority may own a water meter installed within the consumer's premises.

Where, due to unusual lot layouts or for other site specific practical reasons, it is necessary to supply premises via a service pipe of the water authority laid within an easement, only one consumer should be connected to that service pipe.

13.8 Easements and Restrictive Covenants

A water authority's works to be located on privately owned land should be within an easement registered in favour of the water authority in perpetuity. The minimum practical width of an easement for buried pipeline is 6 m (20 feet). Guidelines re water utility easements are available from offices of the Water Management Branch.

Restrictive covenants on use of land may be required to protect a water authority's source of water or works.

13.9 Working Space

Structures and buried facilities should be located within parcels of land and easements in such a way that there will be ample space for access, maintenance and replacement of works.

Storage structures and pumphouses should be located within parcels of land and easements in such a way that additional storage or pumping capacity may readily be added at the site, especially if future expansion of the water authority's service is anticipated.

13.10 Location of Works As-Built

As-built drawings or records of a water system should show by dimensions to the nearest 0.3 m (1 foot) to legal survey lines the location of all buried works, notably wells, mains, valves and service connections. Further, to facilitate finding buried works whose location does not conform to a standard pattern, visual markers should be installed above ground where practical and ferrous tracer tape (or equivalent) should be buried on top of non-metallic pipe.

References

Name	Available from
A.W.W.A. Standards	American Water Works Association 6666 W. Quincy Avenue Denver, Colorado 80235 U.S.A.
British Columbia Drinking Quality Standards	Local Health Unit Offices, Water Public Health Inspection Division, or Ministry of Health 1515 Blanshard Street Victoria, B. C. V8W 3C8
B. C. Power Engineers and Pressure Vessels Safety Act	Ministry of Municipal Affairs Boiler & Pressure Vessels Safety Branch, Safety Engineering Services Division 601 West Broadway Vancouver, B. C. V5Z 4G9
Canadian Standards Assoc. on PVC Pressure Pipe	Canadian Standards Association 178 Rexdale Blvd. Rexdale, Ontario M9W 1R3
Electrical Safety Act	Ministry of Municipal Affairs Electrical Safety Branch, Safety Engineering Services Division 601 West Broadway Vancouver, B. C. V5Z 4G9
Guidelines for Minimum Standards in Well Construction, Province of British Columbia	Victoria & Regional Offices of Water Management Branch or Ministry Environment 810 Blanshard Street Victoria, B. C. V8V 1X5
Navigable Waters Protection Act, Canada	Canadian Coast Guard Navigable Waters 224 West Esplanade West Vancouver, B. C. V7M 3J7
Workers Compensation Act	Workers Compensation Board 5255 Heather Street Vancouver, B. C. V5Z 3L8

APPENDIX 1

ELECTRICAL DESIGN GUIDELINES

General

Successful operation of a pumped water supply system depends on a secure supply of energy and proper control and protection of the equipment. Electrical equipment and supply and control systems must be properly designed, constructed and maintained in order to ensure satisfactory operation and safety to personnel.

The Electrical Safety Branch, Safety Engineering Services Division of the Ministry of Municipal Affairs, publishes and enforces regulations governing construction of electrical systems. The regulations are contained in the current edition of the Canadian Electrical Code Part I as adopted and amended for use in British Columbia.

An electrical installation should be designed by an electrical engineer or technologist knowledgeable in power and control circuitry, electrical protection, safety requirements and the requirements of the water system. Suitable schematic and layout drawings must be prepared prior to commencing the installation or purchasing equipment. The drawings must be submitted to the local electrical inspector, who can often make useful suggestions based on knowledge of local conditions. The electric supply utility should also be contacted for confirmation of electrical supply information.

All new electrical installations must be inspected and approved by the local electrical inspection authority. Connection to the electric utility will be authorized only after the installation is inspected and accepted.

The frequency and length of power outages and the storage capacity and drawdown rate of reservoirs are factors determining the need for standby electric generators (diesel or gas engine driven). A standby system must meet both the Electrical Code and the electric utility's safety standards.

Single-phase services are generally adequate for small electrical systems. However, economics and electric utility regulations usually dictate the use of three-phase systems where motors larger than about 6 kw (8 hp) are required.

POWER AND CONTROL SYSTEMS

Each electrical system requires:

a kilowatt-hour meter owned by the electric utility and installed in an accessible outdoor location;

a service switch (fused or circuit breaker type) which allows the whole of the electrical system to be disconnected from the supply;

power distribution and control equipment for the pumps;

adequate lighting for safe access and maintenance; and

adequate heat and ventilation.

Both manual and automatic control of the pumps are usually provided. Manual control is provided for testing purposes and also to permit pump operation upon failure of the automatic controls. The degree of automation required is a "value judgement" considering safety, economics, convenience and reliability.

Each pump should have the following control:

an adjustable motor circuit interrupter for short circuit protection (fused switches are sometimes used but not recommended here);

a magnetic contactor which incorporates an adjustable, annually resettable, overload protection relay to monitor the motor current and shut down the pump if the current exceeds the motor manufacturer's recommended values;

a MANUAL-OFF-AUTOMATIC control selector switch;

an elapsed time meter to totalize the hours of operation of the pump;

a green indicator light which turns on when the pump is running;

a red alarm indicator light which turns on to indicate pump trouble;

"single phase" protection for three phase systems; and

optionally, an ammeter and phase switch.

Single phasing, which can cause motor burnout, often results when one or two of the electric utility's distribution lines are broken and one phase remains energized. A motor might continue to run when this occurs, although it cannot be started. Higher than normal current and overheating of the motor can result. Overload protectors are generally designed to provide single phase protection. The designer should confirm that the protector selected is adequate, or should provide a separate voltage-sensing type of relay to detect loss of one or more phases and shut down the motors.

A "lead-lag" pump-sequence manual selector switch or an automatic control alternator should be installed to even out the wear of pumps of similar size in a multiple-pump installation, instead of leaving a particular pump in the leading (first started) control position.

Multiple pump systems must have a separate branch circuit for control of each pump. Hence if one circuit fails those serving the other pumps remain usable. Such systems should also have controls designed for time-delayed restarting of the pumps which ensures staggered start-up of the pumps after a power outage, to avoid low voltage which could result in motor overheating, or magnetic controllers and relays dropping out, ie., failing to maintain their contacts closed.

Some motors are equipped with internal non-adjustable devices which can be wired into the external control circuitry to shut down the motor if too hot. Depending on its design, such protection might be acceptable in place of the overload protection relays listed earlier. The controls should be resettable manually to permit return to normal operation after a cooling-off period. Frequent operation of such controls is an indication of pump or motor trouble and should be investigated for the cause.

Well-pump control based on water level in the well is usually accomplished by the use of two electrodes suspended in the well, the upper one being used to start the pump and the lower one to stop it. A third electrode at a still lower elevation can be used as a back-up shut-down device in case the other low electrode fails to stop the pump. A red alarm light requiring the manual resetting should be provided to draw attention to the problem if it occurs.

Control of booster pumps having a steep head-discharge curve is usually achieved by means of pressure switches sensing suction and discharge line pressures. Booster pumps with flat curves may be controlled by switches sensing pressure to start and flow to stop. "Hunting" of the controls, ie., rapid start-stop sequencing, resulting from pressure surges or from pumping into a hydro-pneumatic tank can be prevented by use of time delay controls. A harmfully low suction pressure can be sensed by a pressure switch wired into an alarm system.

Storage tank water levels can be maintained by the use of a minimum of two electrodes or pressure switches, one arranged to sense a low level and hence used for permitting operation of the pumps, the other sensing high level and used for preventing operation of the pumps. One such pair is commonly used per pump. Other electrodes or switches can be installed and connected for high or low level alarms.

ALARM SYSTEMS

An alarm system provides warnings of trouble. Its signals can be transmitted by leased telephone lines, private lines or radio to an agency headquarters or a private home. Alternatively, it can be designed to operate a light or audible device in a prominent location to attract attention. A separate electrical contact provided for each of the following alarming conditions can be used to initiate a general alarm signal:

motor overload;
power failure;
low pressure;
low reservoir level;
high reservoir level;
security (break-in);
pump control failure; and
standby generator trouble.

The system design should make it possible to differentiate the individual causes of alarms.

CONSTRUCTION

Electrical equipment should be housed with good ventilation, preferably above ground. Underground structures are usually acceptable only when natural drainage is assured, to avoid flooding due to seepage or leakage. Floor drains should be provided with P-traps or screens to prevent entry of vermin.

Power, control and alarm wiring installed on poles is usually the least expensive form of construction but might be susceptible to damage from falling branches or trees, or vehicle accidents. Underground wiring can be directly buried or pulled into buried electrical ducts. Warning tape buried about 1/2 metre (1 1/2 feet) above the underground wiring cautions anyone excavating in the area.

If mounted outdoors, electrical equipment must be suitably enclosed and protected from moisture, extreme temperatures and vandalism. One metre (3 feet) minimum working space should be provided in front of the equipment for maintenance. There should be ample room for removal of pumps and motors. Overhead wires must have proper clearance over vehicle access and be away from hatches.

OPERATION AND MAINTENANCE

Where practicable, the electrical system designer should attend start-up to check all the protection and explain the operation of the system.

A copy of electrical drawings, manufacturers' handbooks, and a step-by-step explanation of the control logic should be kept in a convenient, safe and dry place, normally in the pumphouse.

Any well designed and constructed system can fail because of inadequate maintenance. All electrical equipment should be inspected and all functions checked annually, with records kept of the motor currents and voltages and the maintenance work done.

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